Row, row, row your boat

"It is not possible to step twice into the same river."
—Heraclitus

ONE OF THE EARLY ARGUMENTS against a spinning Earth held that objects would not fall straight down. Given that we now know (with the help of Eratosthenes) that our home planet has a diameter of 6,500 km (4,000 miles), then parts of our planet must be moving at 1,700 km/hr (1,000 mph). If the critics had been correct and you drop an object that takes 0.5 s to reach the ground, the object would land 240 m behind you. Along comes Galileo to refute what appears to be common sense.

Galileo proposes that a person climb the mast of a ship. If the ship is not moving and a ball is dropped, it will certainly fall straight down. The defenders of the stationary Earth would then predict that if the ship were moving, the ball dropped from the mast would land toward the rear of the boat. This is because, they would say, the boat glides forward while the ball is descending. Galileo suggested the correct behavior. The ball maintains the original horizontal motion of the ship and lands in the identical location as when the ship stood still.

If this works for a ship, it should also work for the Earth. The vertical motion is independent of the horizontal motion. A ball on a stationary ship or a gliding ship will land in the same place whether the ship is moving or stationary. This may seem obvious to some of our readers, but it is quite subtle and still confounds some people.

Imagine hopping aboard a rowboat and paddling from one shore to the opposite shore with no current. The trip takes you 15 minutes. If you return to the river and venture across again, paddling to the opposite shore with the same strokes, but with a stiff current dragging you downstream, will you arrive at the opposite shore in less time, in more time, or in the same time? You probably recognize that your would land further downstream on this second

Through the image streams a river with two very different shores on each side. The one symbolizes life, the other death. The life side is the sunny side, people are enjoying themselves under the tree of life, eating, drinking, writing, painting. The opposite side is the dark side, where the trees are chopped down and Time stands still. Our hero has to paddle across the river from point A to point B, but God forbid life would be that easy, the river is wild and treacherous and he gets dragged downstream, undergoing several life-threatening misadventures, until he reaches the other shore as an old man. Now he has to drag himself up to get to point B as planned, where he apparently bites the dust, though we see him right after that ressurrected as a young boy crossing the river to the shore of the living again. Some people never get enough.

—T.B.


A
B
E=mc²
Tom Bunk

journey. Since you traveled further, maybe it should take more time. But your velocity is actually the sum (the vector sum!) of your paddling velocity and the velocity of the current. With this faster speed, maybe the journey should take less time. Or perhaps, the longer distance is exactly compensated by the greater speed and you arrive at the opposite shore in the same time. Our readers can use the fact that the motion across the river and the motion downstream are perpendicular to each other and are therefore unaffected by each other. The time is determined by the motion across the river independent of the speed of the current. The current determines where the boat lands downstream, but does not change the time.

Once again, this is quite subtle, and our readers should attempt to explain the solution of this puzzle to people not accustomed to thinking the way physicists do. If you can convince someone of this, then you, as a teacher, must really understand it.

Let's complicate the situation. What happens if you don't paddle straight across the river, but rather choose to paddle at some angle? Now you'll find that there is a component of your velocity that helps you across the river and a component that takes you upstream or downstream. In this way, you can head upstream and end your journey directly across from where you embarked.

So here is our problem. Assume that you wish to end up directly across the river and that you were permitted to walk on the far shore if you land upstream or downstream. What path takes the least time? Let's add some specific numbers (suggested by Resnick and Halliday in their *Fundamentals of Physics*): the river is 500 m wide; your rowing speed is 3,000 m/h; the river flows at 2,000 m/h; and your walking speed on the opposite shore is 5,000 m/h.

A. Solve for the possible range of angles qualitatively.

B. Describe the path quantitatively.

C. Calculate this minimum length of time.

". . . Merrily, merrily, merrily, merrily, life is but a dream."

Solution